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STRENGTHENING MICROARTICLES MADE OF FORSTERITE CERAMICS BY IMPREGNATION IN SALT SOLUTIONS

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The results of experiments in strengthening miniature bushes with outer diameter 1.2 – 3.5 mm made of forsterite ceramics by impregnation in salt solutions are discussed. It is demonstrated that an increased temperature of the first firing and a decreased impregnation duration increases strength by 47% up to 2.7 times, depending on the size of the product. Mathematical processing of experimental results is implemented using the spline smoothing interpolation method.

An effective method for controlling properties of ceramic materials is impregnation of porous intermediate products in salt solutions before final firing [1]. This method was used for the first time to strengthen and increase heat resistance of forsterite ceramics LF-1. The static bending strength in that case was increased to 280 – 310 MPa against 160 – 170 MPa in initial ceramics. This was achieved by impregnating an article after a first firing in boiling aqueous salt solutions (5% solution of chromium chloride or 10% solution of ammonium alum) and subsequent sintering at a temperature of 1603 – 1633 K.

Production of articles of size 5 – 15 mm implies impregnation of intermediate articles for 120 min for its saturation with salt to a required depth. The thickness of the strengthening layer in this case is comparable to the wall thickness of miniature bushing, whose geometrical sizes are indicated in Table 1.

Bushes are produced by hot injection molding and due to their miniature sizes their mechanical strength needs to be raised, which is possible if the thickness of the strengthening layer decreases relative to the bush wall thickness. To do this, it is necessary to reduced the impregnation rate, which can be achieved by decreasing the porosity of the intermediate product and shortening the impregnation duration.

To decrease the porosity of the intermediate article, the first firing temperature was gradually raised from 1273 to 1533 K. Next, samples were impregnated in a boiling solution of ammonium alum $(NH_4)Al(SO_4)_2 \cdot 12H_2O$ for 5, 15, 30, 60, and 120 min.

The tensile strength of sintered bushes was tested under diametrical compression [2].

The plots of dependence of strength (experimental data) on technological parameters are constructed using the Surfer 3D graphic package (Fig. 1). Smoothing and determination of intermediate points was carried out using two-dimensional

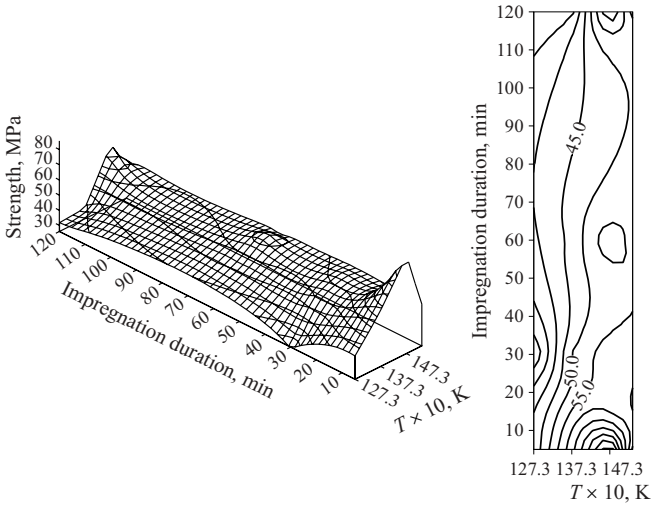

Fig. 1. Dependence of tensile strength of bushes with outer diameter 1.2 mm on temperature of preliminary firing and duration of their impregnation in 10% ammonium alum solution.

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TABLE 1

Bush diameter, mm		Bush height, mm
outer	inner	
3.5	2.6	3.4
2.3	1.5	1.7
1.2	0.7	0.4

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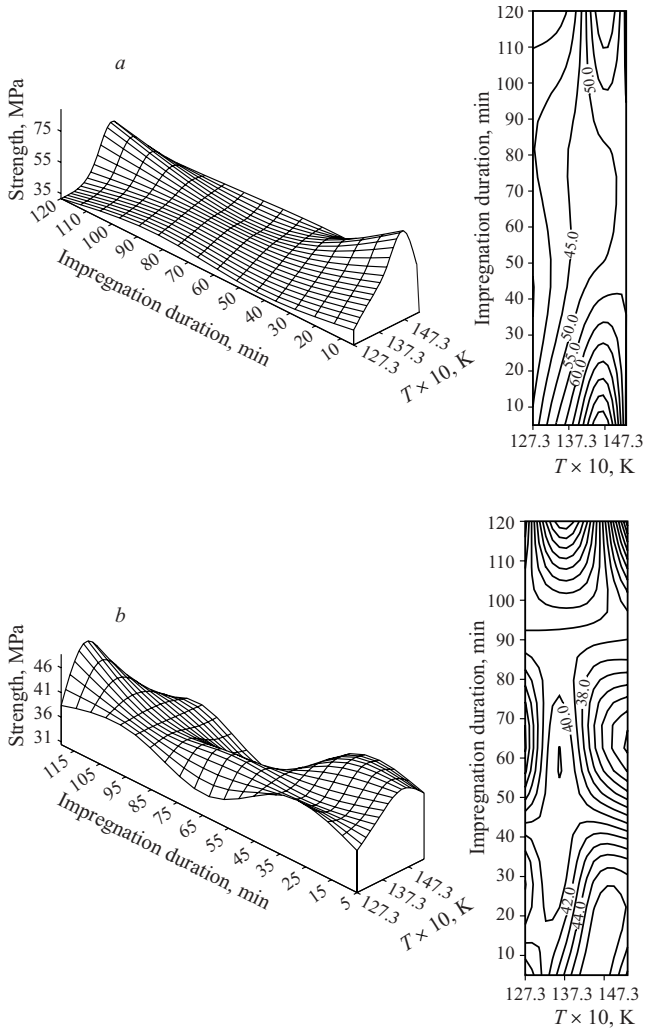

Fig. 2. Smoothed surface of dependence of tensile strength of bushes with outer diameter 1.2 mm (*a*) and 3.5 mm (*b*) on temperature of preliminary firing and duration of their impregnation in 10% ammonium alum solution.

TABLE 2

Bush outer diameter, mm	Wall thickness, mm	First firing temperature, K	Impregnation duration, min	Tensile strength, MPa
3.5	0.45	1400	15 – 28	44
2.3	0.40	1400	5 – 20	55
1.2	0.25	1450	5 – 10	> 80

spline-smoothing interpolation, which is an option in the package specified. Its results are shown in Fig. 2.

It can be seen that increasing the first firing temperature and reducing the impregnation duration significantly raise the strength of materials and articles (Table 2). Thus, the strength of bushes with an outer diameter of 3.5 mm grows by 47% and that of bushes with diameter 1.2 mm grows 2.7 times.

It is established that the strength of material of strengthened and non-strengthened bushes grows as its volume decreases, which may be related to the scale factor of strength [3].

Thus, in strengthening miniature forsterite ceramic articles by impregnation in salt solutions, it is necessary to raise the first firing temperature and to reduce the duration of impregnation of articles.

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